Journal of **N**onlinear **A**nalysis and **O**ptimization
Vol. 14, Issue. 2, No. 2: 2023
ISSN : **1906-9685**

DIGITAL TWIN IS A REAL-TIME DIGITAL CLONE OF A PHYSICAL DEVICE

Ms.N Thamarai Selvi, MCA, Assistant Professor, PG Department of Computer Applications, Marudhar Kesari Jain College for Women, Vaniyambadi

Abstract:

Digital twin technology is a new technology applied in manufacturing industry. Different types of digital twins may be identified based on the connection and data stream between the physical object and the digital twin. This research focuses on the description of the main features of this new technology and on the newly developed applications due to corporate digital transformation process in the manufacturing industry. Digital transformation in corporate world open up new possibilities for application options of digital twin technology. External data sources such as social media may also be applied for designing and making digital twins in the process of corporate digital transformation process. The development of corporate digital transformation such as artificial intelligence solutions has also opened up new development options. The research elaborated these new ways and industrial examples.

Keywords: Digital Transformation, Data Analytics, Artificial Intelligence, Real-time Communications, Network Requirements

Introduction

There are plenty of definitions of a "**Digital Twin**" flooding all over the Internet but the simplest is: ***A Digital Twin is a real-time digital clone of a physical device.*** Still ambiguous? Let me make it unambiguous. A Digital Twin of any device/system is a working model of all components (at micro level or macro level or both) integrated and mapped together using physical data, virtual data and interaction data between them to make a fully functional replica of the device/system and that too on a digital medium. This digital twin of the physical system is not intended to outplace the physical system but to test its optimality and predict the physical counterparts' performance characteristics. You can know of the system's operational life course, the implication of design changes, the impact of environmental alters and a lot more variables using this concept. Talking about life course, it invites me to aromatize your awareness of the concept with its origin.

How does a digital twin work?

The power of digital twins comes from connecting real-world assets with real-world data, so you can better visualize them. Digital twins enable cross-functional teams to collaboratively design, build, test, deploy and operate complex systems in interactive and immersive ways. They help companies understand the past, view present conditions, and prevent future problems. They inform decision-making through sales and marketing insights, analysis, 3D visualization, simulation, and prediction.

History of digital twin technology:

The concept of using a digital twin as a means of studying a physical object was first introduced by NASA in the 1960s. NASA replicated its spacecrafts at ground level to match the systems in space for exploration missions. This technology was notably demonstrated in the Apollo 13 mission. Through the connected twins, Mission Control was able to quickly adapt and modify the simulations to match the conditions of the damaged spacecraft and troubleshoot strategies to bring the astronauts safely home.

In the early 1970s, mainframe computers were used as digital twin-esque systems to monitor large facilities such as power plants. In the 1980s, 2D CAD systems like AutoCAD emerged to produce technical drawings, making it possible to design anything with a computer, and were quickly adopted by millions of designers and engineers.

`By the 2000s, 3D CAD with parametric modeling and simulation enabled the design of more complex assemblies in more intelligent ways, like a database of interconnected objects. Fast-forward to the mid-2010s when all leading 3D CAD vendors launched cloud-connected solutions, primarily for collaboration and project management, and gradually for generative design, although CAD tools remained desktop-based.

Our present day marks the genesis of the age of real-time 3D powered digital twins, going beyond dashboards and 3D models to unlock data from multiple sources on any device or platform for better collaboration, visualization, and decision-making.

TYPES OF DIGITAL TWINS:

There are various types of digital twins depending on the level of product magnification. The biggest difference between these twins is the area of application. It is common to have different types of digital twins co-exist within a system or process. Let’s go through the types of digital twins to learn the differences and how they are applied.

1. Component twins/Parts twins

Component twins are the basic unit of digital twin, the smallest example of a functioning component. Parts twins are roughly the same thing, but pertain to components of slightly less importance.

2. Asset twins

When two or more components work together, they form what is known as an asset. Asset twins let you study the interaction of those components, creating a wealth of performance data that can be processed and then turned into actionable insights.

3. System or Unit twins

The next level of magnification involves system or unit twins, which enable you to see how different assets come together to form an entire functioning system. System twins provide visibility regarding the interaction of assets, and may suggest performance enhancements.

4. Process twins

Process twins, the macro level of magnification, reveal how systems work together to create an entire production facility. Are those systems all synchronized to operate at peak efficiency, or will delays in one system affect others? Process twins can help determine the precise timing schemes that ultimately influence overall effectiveness.

CHARACTERISTICS OF DIGITAL TWIN TECHNOLOGY:

Digital twin technology comprises certain characteristics such as connectivity, homogenization, re-programmability, digital traces, and modularity.

- ✓ *Connectivity*

In digital twin technology, we embed connectivity between physical assets and their digital counterparts. We attach sensors to physical objects to enhance their connectivity with their digital representations.

Data from the physical components is obtained and integrated via these sensors. This integration enables the sensors to communicate the collected data to a user.

- ✓ *Homogenization*

Digital technology is also characterized by the homogenization of data from physical components. This means that a digital representation similar to the physical object can be created using the collected data. This technology can also enable data to be decoupled from the physical artifacts.

- ✓ *Reprogrammable*

A digital twin can enable the replicated physical product to be reprogrammed. This can be used as the basis for creating new versions of the initial product.

A good example of this in the case of engines. A digital twin for a current engine can be reprogrammed to improve fuel efficiency and productivity.

- ✓ *Digital traces*

This technology consists of digital traces that are left when creating a digital twin. Digital traces are used by engineers in the diagnosis of problems when machines break down.

- ✓ *Modularity*

Digital technology enhances the customization of digital production modules. This enables manufacturers to modify their models. Modularity in digital technology enables manufacturers to identify areas that need improvement.

Applications of digital twin technology:

The digital twin technology is applied in various industries. The following are some use cases of this technology.

- ✓ ***Manufacturing***

Digital twins are used for replicating the physical processes in manufacturing companies. Digital technology enhances the interaction of virtual objects and physical objects in the factory.
When there are problems in the actual physical processes, engineers assess the digital twin to trace the problem's origin and nature. Digital twins in manufacturing can also be used to improve processes.

- ✓ ***Health care***

Through digital twin technology, health professionals can create personalized models to improve medical care. These professionals can use the digital twin of organs or patients (instead of real patients) to practice important health procedures.

- ✓ ***Urban planning***

Digital twin technology is important in the planning of smart urban cities. Digital twins are used for modeling urban cities and related data.

This technology has also enhanced the digitization of related activities such as construction, maintenance, and operation of urban projects. It integrates the built project with its digital replica to enhance optimal performance.

- ✓ ***Automotive industry***

Automobile companies use digital twin technology to create digital twins of their cars. These digital twins enable these companies to showcase how real cars operate.

In case improvements are needed with the current car models, engineers will use the digital twins to suggest new features that can improve their performance.

Digital twin challenges:

It's one thing to gather extensive data, but it's quite another to consume it in an intelligent way. The best decisions are made using data, but your data is only as good as your ability to bring it to life to simulate and predict business scenarios.

Every enterprise going through a digital transformation risks drowning in raw data before finding a way to process and leverage it. Today, capturing raw data is less of a challenge than processing it, filtering the useless parts, combining it, and transforming it into information that makes sense to the user in the context of their application.

The main challenge is unlocking the power of information. Enterprise and IoT data has been buried in databases, spreadsheets, and models (CAD, BIM, GIS). Real-time 3D digital twins can bring that data to life.

Digital Twins with Machine Learning offer a compelling solution

New software technology called Digital Twins can improve rail safety by adding intelligent real-time monitoring to the rail system and creating timely alerts when problems arise. Digital twins can simultaneously monitor thousands of assets, such as rail cars and switches, to continuously look for emerging issues. For example, Digital Twins can track all rolling stock to detect impending wheel bearing failures. Because each Digital Twin can independently correlate data from multiple hot box detectors and combine this with other relevant information, such as the wheel bearing's service issues and the ambient temperature, it can precisely identify the conditions which indicate an impending wheel bearing failure.

To accurately decipher what is or isn't an issue and signal an alert only when a real problem is occurring, Digital Twins can incorporate machine learning algorithms that identify patterns in the data indicating an emerging problem, such as an overheated wheel bearing. To analyse wheel-bearing temperatures, machine learning algorithms use training data from thousands of detectors to learn which patterns of temperature measurements need alerting. They enable Digital Twins to provide fast, powerful analytics.

Digital twins can also monitor switches, crossings, and train positions to look for conflicts that could lead to collisions. For example, in the Dutch accident, a train unexpectedly collided with a crane. A Digital Twin of the crane that was blocking the tracks could exchange information with other Digital Twins of approaching trains to detect a conflict and generate an alert. Having Digital Twins monitor key assets provides another layer of safety that can help avoid accidents.

Using thousands of Digital Twins to provide real-time monitoring requires a fast, scalable computing platform. In-memory computing technology can host Digital Twins and enable fast access to data. This technology automatically distributes the processing workload across multiple servers to reduce analysis times down to milliseconds.

How are digital twins and internet of things (IoT) related?

Digital twins are visualizations built from conceptual models (e.g., BIM, CAD, or GIS) or scans of physical entities (e.g., manufactured products or facilities). The Internet of things (IoT) refers to a network of physical objects that possess unique identifiers (UIDs) and contain embedded technology. This enables them to communicate and interact with other objects over the internet, collecting real-world and real-time data. When digital twins integrate with IoT data, they can provide insights into the performance of an asset at specific points in time, and help users evaluate potential outcomes and plan resolutions.

With access to IoT sensors and data, digital twins can capture a holistic view of the virtual model to unlock deeper operational intelligence. For example, a digital twin of an engine might contain information about its performance characteristics and allow engineers to run simulations to test new designs or measure the impact of future changes.

While there are many different types of digital twins, they all share a number of common characteristics. They use digital representations of physical objects and systems, contain UIDs so that they can be easily identified by devices on the internet, and allow for bidirectional communication between themselves and physical IoT devices to exchange information and coordinate actions.

Model rail networks with Digital Twin simulations

The flexibility of Digital Twins also enables to implement simulations that test their monitoring capabilities and accuracy before deployment in a live system. Simulations allow system designers to model complex rail networks and ensure that monitoring techniques will successfully detect issues and generate alerts when needed.

For example, to demonstrate how Digital Twins can detect wheel bearing failures, ScaleOut Software created a simulation of the U.S. freight rail system using its ScaleOut Digital Twins technology. This simulation modelled thousands of trains and injected random cases of deteriorating wheel bearings to validate that Digital Twins can track wheel-bearing temperatures from multiple hot box detectors and alert engineers before failures occur.

Keeping our railways safe:

Railways are the backbone of the modern supply chain and a cornerstone of public transportation. However, today's rail monitoring infrastructure often falls short of detecting emerging issues, leading to costly accidents.

New technologies, like Digital Twins, machine learning, and in-memory computing, can build on existing rail infrastructure to provide continuous monitoring, identify problems, and boost situational awareness for personnel. They have the potential to significantly reduce the current frequency of accidents and pave the way for a safer, more efficient, and reliable transportation system.

Conclusions

The digital twin technology can not only make use of the theories and knowledge of human beings to establish virtual models, but also make use of the simulation technology of virtual models to explore and predict the unknown world, and find better ways, constantly stimulate the creative thinking of human beings, and continue to pursue the optimization and progress, which are the innovation of the current manufacturing industry. This chapter mainly summarizes the definition, connotation and implementation methods of digital twin technology

References

1. *Grieves, Michael (October 31, 2002).* "Completing the Cycle: Using PLM Information in the Sales and Service Functions". Retrieved November 19, 2022.
2. *Grieves, Michael (October 5, 2015).* "Can the digital twin transform manufacturing". *World Economic Forum Emerging Technologies*. Retrieved November 19, 2022.